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Inorganic materials and their use in polymeric materials

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Abstract

The presented paper deals with the preparation inorganic materials and their use as filler in the polymeric rubber blend. The influence of used quantity of filler was evaluated from result of curing characteristics (minimum torque, maximum torque, optimum cure time, processing safety, rate coefficient of cure) and physical-mechanical properties (tensile strength, elongation, hardness, young's modulus). All these properties of polymeric rubber blends were compared with properties reference blend.

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Keywords: inorganic materials; eggshell; filler; curing characteristics; mechanical properties

1. Introduction

Polymer materials with inorganic fillers, such as silica nanoparticles, carbon nanotubes, glass fibers and nanofibers have been studied extensively over the past two decades. Inorganic mineral fillers like calcium carbonate ($CaCO_3$), talc and silica have gained interest from the aspect of the low-cost fillers for polymeric materials. These inorganic mineral fillers offer significant enhancement in stiffness, rate and thermal stability. There has been growing demand for green and renewable substitutes for inorganic fillers [1, 2].

Eggshell (ES) is a solid waste produced in manufacturing plants and food processing, amounting to several tons per day. The most of the eggshells is sent to the landfill at the high management cost without further processing. Therefore, it is economical to use eggshell waste for transforming biomaterials into commercial products and

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creating new values from these waste materials [3]. ES is constituted by a three-layered structure, namely the cuticle on the outer surface, a spongy-calcareous layer and an inner lamellar layer [4]. The chemical composition of the ES has been reported to consist of calcium carbonate (94%), calcium phosphate (1%), magnesium carbonate (1%) and organic matter (4%) represented by the type of X collagen, sulfated polysaccharides, and other proteins [3, 5, 6]. Studies have shown that eggshell is able to replace the commercial $CaCO_3$ up to 75 % and talc can be used as new bio-filler into polypropylene composites [4].

In this study, we added the eggshell into the blend in order to replace the conventional filler (carbon black – CB) in an amount of 1 phr, 3 phr and 10 phr. We evaluated the impact of the prepared fillers on properties of the resulting blends and vulcanizates. We studied changes of parameters of curing characteristics for non-cured tread rubber blends as well as physical-mechanical properties of resultant vulcanizates. The results were compared with values of reference blend without addition of prepared inorganic ES filler.

2. Preparation inorganic ES filler

The raw inorganic material – eggshell (Fig. 1) was washed and dried for 24 h in dryer at temperature of 70 °C in order to eliminate contaminants and odour and then it was grinded and filtered through a sieve with mesh size of 40 μm.

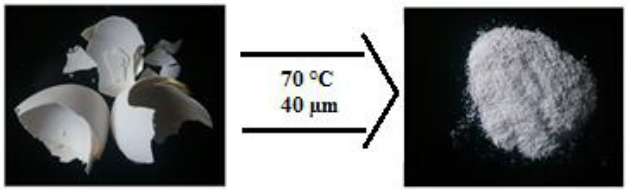

Fig. 1. Preparation of inorganic filler – eggshell.

3. Preparation of rubber blends

Preparation and mixing of rubber blend is one of the most important processes of rubber technology. The tread blends with inorganic ES materials were prepared by two-step mixing in laboratory mixer of Brabender type with chamber volume of 70 cm^3 and 50 revolutions per minute and the procedure was done according to STN 62 1425 (Slovak Technical Standard). The mixed tread blends were homogenized during the first and the second steps in laboratory two-roll mill device.

Processing capacity of a rubber compound can be predicted using their curing characteristics [7]. Determination of cure characteristics was carried out by MONSANTO vulcameter at the temperature of 150 °C during 60 min.

4. Preparation of rubber vulcanizates

The prepared vulcanizate test specimens were cut out in the shape of the double-sided blades and then the physical and mechanical properties were determined. Tensile properties were determined using INSTRON universal testing machine. The tensile strength, elongation and young's modulus were evaluated properties [8]. Hardness of vulcanizate was measured by IRHD hardness tester. The measured values of tread blends were compared with reference blend. The composition of fillers in samples is shown in Table 1.